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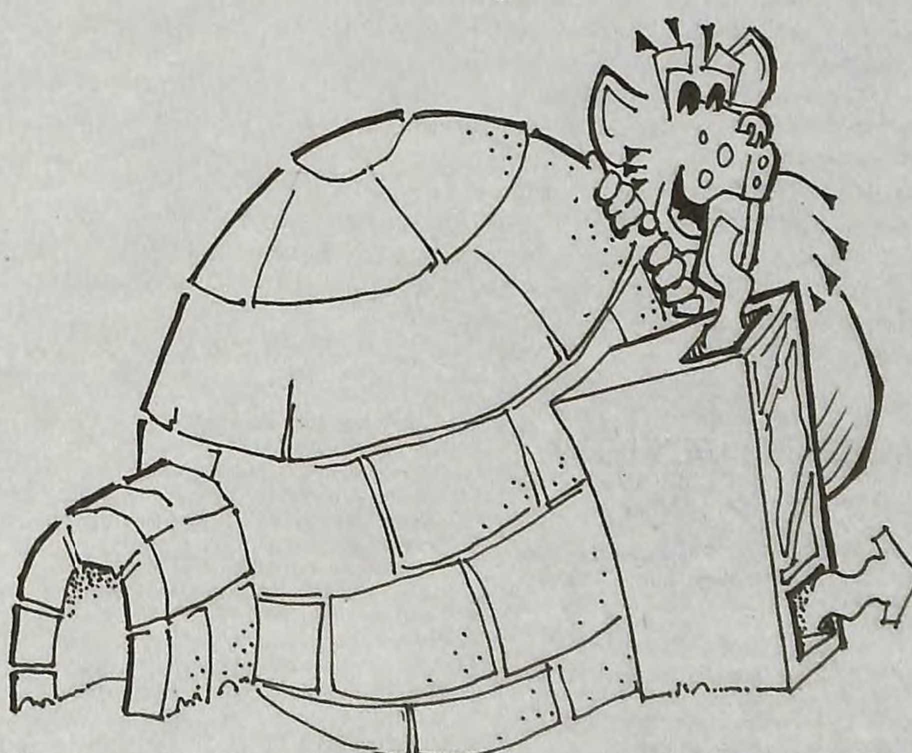

From the Editor . . .

This summer we've been confronted with interesting discussions about science, research and scientific facts, and how much statistical data needs to be collected. Our current federal government policy increasingly seems to be made on the basis of whim, gut feelings and ideology. It seems that little in the way of knowledge or scientific proof is going to interfere when they've made up their mind. When they make up their mind they don't want to be confused with the facts – and this from a government that prides itself on sound business management.

However, few business decisions are made strictly on gut feelings or ideological belief. It is the exceptional entrepreneur that can take such a risk – and success depends as much on luck.

I've been on enough committees over the last number of years to know that when substantial decisions need to be taken, questions are raised and research is done to carefully consider what is happening now and what the impacts are. Invariably, as decisions become significant, such as code changes, a lot of work is done to determine exactly what the current situation is, whether it is a problem that actually needs to be fixed, what the solution may be and what the potential impact of the changes may be.

This is also why continuing research is needed – to keep our body of knowledge current. Yet, it is regrettable to see that support for research is waning. Research budgets are being cut back, if not eliminated altogether. The brouhaha over the census is just the latest, high profile example of the denigration of research, since the census provides a valuable treasure trove of data not only for pointy-headed academics and do-gooders to study, but also for policy makers at all levels, to help make better decisions about policy.

The development and construction industry also needs the data to help identify where and what kind of housing and development is going to be needed – in other words, where the market is going. No amount of voluntary surveys will generate such comprehensive data.

Research cutbacks are especially a concern in the construction industry because it is an industry that is not vertically integrated – there is no single organization that can tackle large-scale research studies, funded out of regular continuous cash flows. Rather, this industry has many smaller players that do not have the deep pockets and resources to undertake much fundamental research that needs to be done, especially since cash flow is organized strictly around specific projects that usually have a relatively short duration.

I've observed that even those agencies with some funds for research are being restricted to the amount and kind of work they can support. They need to go cap in hand to try and create funding consortia to undertake specific research projects. Such projects then tend to be very specific, and don't always address a fundamental search for knowledge.

In the construction industry there is a perception that because we've been building buildings for a long time all that is to be known about building is known, so there is not much need for more research. A few years ago we even had a senior officer of the National Research Council musing about reducing activities in the construction sector because there was little new to be learned. This overlooks, of course, the effects of new materials, new energy performance requirements, new designs, changes in lifestyles, climate change, and many other things that have changed what and how we build.

We really need to impress on government that there is a need to expand our efforts into research, and that decisions need to be taken based on factually sound principles and not ideological gut feelings for what may or may not need to be done.

Richard Kadulski,
Editor

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Editor-Publisher: Richard Kadulski
Illustrations: Terry Lyster
Contributors: Don Fugler, Thomas Kovesi, Rob Dumont, Janet Ansell, Mark Gauvin, Phalguni Mukhopadhyaya
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e-mail: solplan@shaw.ca
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Ventilation effectiveness
Health Benefits of Heat Recovery Ventilators

HRVs provide increased ventilation, improve indoor air quality and significantly reduce respiratory symptoms in young children.

To maintain good indoor air quality requires continuous air change. Attention to the proper design of this air change is especially important, as today's homes are more airtight than in the past. Reliance on incidental air change to maintain adequate conditions inside is no longer good enough. Lower ventilation rates in homes have been associated with increased risk of respiratory infections.

In northern Canada, this is especially important given the severity of the climate because northern homes are much smaller than southern houses and have higher occupancies, leading to unhealthy indoor conditions.

While their footprint may resemble small southern houses, northern houses typically have no basements as they are raised above the ground because of permafrost. Basements commonly double the volume of a bungalow and add 50 per cent to the volume of a two-storey house. Without a basement there is less room for mechanical systems, material storage, play areas, etc. Thus, any pollutant introduced into the house will have a smaller amount of air to dilute its effect.

Indoor measurements in a number of Nunavut homes have found that CO_2 concentrations, which can be used as an indicator of adequate ventilation and indoor air quality, ranged up to 5,000 parts per million (ppm) and averaged between 1,000 and 2,000 ppm in the houses surveyed. These concentrations are higher than those found in most southern Canadian houses. Outdoor background concentrations are around 400 ppm.

Health Concerns

Low ventilation rates are common in many homes in the north. These communities also have some of the highest reported rates of hospitalization for severe respiratory infections in children – in the order of 300 per year for each 1,000 infants. Many have to be flown to children's hospitals in southern Canada for treatment, and they may experience serious long-term pulmonary complications.

Because it is not clear why this rate of infection is so high, a multi-year study to determine whether house conditions were a contributing factor was undertaken. The medical study was led by Dr. Thomas Kovesi of the Children's Hospital of Eastern Ontario and involved researchers from Carleton University, CMHC, Natural Resources Canada, Nunavut Department of Health, Nunavut Housing Corporation, Health Canada, Venmar Ventilation Inc. and others.

Research Studies

Two preliminary studies looked at the potential effects of Nunavut housing on the transmission of disease. Although many of the indoor air quality indicators were within the normal range, it is clear that a large number of Nunavut houses are not being adequately ventilated. A high proportion of smokers and the associated second-hand smoke indoors, along with high and variable occupancies also play a part in the indoor air quality.

Building on these preliminary studies, a more ambitious project was undertaken to look for correlations between poor indoor air quality (IAQ) and the frequency of respiratory infections. The premise of the research project was that ventilation, to provide more fresh air, could be increased through the installation and operation of a heat recovery ventilator (HRV) and that the increased ventilation rates would result in better child respiratory health.

HRVs recover much of the energy used to ventilate so are a desirable ventilation system in a cold region with high heating costs.

An interesting feature of this project is that like typical medical research projects, the sample was designed to have a test group and a control group with placebos. The test sample was divided into two groups of houses: those with active HRVs and those with "control HRVs" that were installed and operated but did not introduce fresh air to the houses. The results were tracked over a winter.

The project aimed to have 100 HRVs installed, with that number split equally between active HRVs and control units, to detect health effects. The HRVs were modified by the manufacturer (Venmar Ventilation Inc.) so that an additional 25-30 litres per second (L/s) of ventilation air would be added to the test houses. The control HRVs were adjusted to operate by circulating inside air, without bringing fresh outdoor air inside.

At the end of the monitoring period all control HRVs were returned to standard full operation.

Study Results

The results showed that the HRVs provided increased ventilation as expected. The houses with active HRVs had lower mean CO_2 concentrations, which would indicate that occupant-generated pollutant concentrations are also lower. The highest CO_2 concentration in the active HRV sample was about 1800 ppm, while the highest house with a control HRV (i.e. no ventilation) had more than 3500 ppm of CO_2 during the measurement period.

It was also noted that the houses with operating HRVs were slightly cooler and had lower relative humidity levels than the houses with placebo installations. Lower humidity levels in these houses are not necessarily a benefit. The cooler temperatures can be expected, as no HRV is capable of recovering 100% of the energy from the exhaust air, so there will be a slight cooling effect that needs to be offset by the heating system.

Complaints by residents about the HRV noise, discomfort or low humidity were common but similarly spread between those with active HRVs and those with placebos. Active and placebo HRVs were equally apt to be unplugged by residents. This underlines the importance of careful system design and installation to minimize these issues.

The study team found that the HRVs did what they were supposed to do: they increased the ventilation rate, and indoor air quality indicators such as CO_2, were reduced. They concluded that improving ventilation significantly reduced the incidence of important respiratory symptoms in young Inuit children.

Being a study of far northern housing, the researchers also point out that the information should help improve the design of mechanical ventilators to improve system design to better suit the needs of Inuit families living in the far North. They also point out that a multifaceted approach, including reducing overcrowding by providing more housing stock, improving indoor ventilation, decreasing environmental tobacco smoke exposure, and enhancing immunization strategies, will be necessary to reduce the burden of lower respiratory tract infection and chronic disease in Inuit children.

The conclusions about the impact of improved ventilation on respiratory health have been reported in several peer reviewed scientific journals including the Canadian Medical Association Journal and Indoor Air.

Installation Challenges

The ideal way to install HRVs is to have exhaust ducts taking air from the kitchen and bathroom and deliver fresh air to the bedrooms. However, retrofitting HRV ducting inside of small, existing homes was a problem. Building chases around exposed ductwork would have added greatly to the inconvenience of the householders and to the project cost, so that houses were selected for ease of installation – where HRVs could be installed either to tie in to existing forced-air heating system ducting or to be located in an unused internal (but heated) crawl space with the ducting run inside that space.

For HRVs attached to forced-air heating systems, the HRV operation was linked to the forced-air heating system usage so that fresh air was provided primarily when the heating system was in operation, which would result in better tempered (and less noticeable) fresh air. In the shoulder seasons, when the furnace was not running as frequently, a timer activated the furnace fan on an hourly basis and the fresh air from the HRV was distributed by the furnace fan. The HRV flows were adjusted so that the average hourly target of 25-30 L/s was achieved even with only sporadic usage. The HRVs installed in crawl spaces had continuous flows at this rate.

The study provided valuable evidence about the importance of proper ventilation on indoor air quality and occupant health. The ventilation increase resulting from HRV usage is both measurable and beneficial to health.

However, it also provided other valuable lessons. Because of the remote locations and small communities, where building materials arrive only once or twice a year by boat, detailed planning of system design and careful take-offs for all supplies and materials must be done far in advance of construction. In most cases, this meant not having recruited households suitable for the study.

In addition, contractors, both mechanical and electrical, to do the installations were hard to locate and had variable expertise. Very few lived in the communities where the HRVs were being installed, so that there was little technical follow-up or troubleshooting available.

Because of these challenges, the actual number of houses surveyed was smaller than originally planned for, although the results still provided valid data.

It is clear that retrofitting of HRVs into existing housing will require some adjustments by residents and contractors. Robust technical support by local contractors and housing authorities is also important. Although this study took place in isolated communities of Nunavut, many of the same issues would also apply even in much larger, less isolated communities.☼

references

***Indoor air quality and the risk of lower respiratory tract infection in young Canadian Inuit children**, Canadian Medical Association Journal, 177:155*

***Heat recovery ventilators prevent respiratory disorders in Inuit children**, Indoor Air 2009: 19: 489*

A CMHC Research Highlight is being prepared and will concentrate on the housing-related aspects of the study.

Ventilation – Why Do We Need It?

In our heating climate, the pursuit of thermal comfort and energy efficiency has resulted in the focus on the use of more insulation and good air sealing of homes. Some think we have gone too far in air sealing our houses, compromising indoor air quality. However, air sealing is important not just as an energy conservation concern, but also to ensure a more durable building envelope – to prevent moisture problems as a result of interior moisture condensing on colder elements within the construction assembly.

Traditionally, a significant portion of the air change in houses was generated by the airflow up the flue of natural draft appliances, such as furnaces, wood burning fireplaces, and wood or oil stoves, and through cracks and holes in the building envelope. Houses were not airtight – in fact, they were often very drafty. That uncontrolled air change kept the indoor environment somewhat within acceptable conditions. However, studies done by CMHC a number of years ago showed that in fact even some very leaky old houses had worse indoor air quality than newer homes that had basic, code compliant mechanical ventilation systems.

When ventilation is inadequate or ineffective, moisture generated by people and household activities, along with odours and carbon dioxide, will accumulate, raising the interior humidity level and lowering the indoor air quality. This can lead to mould, mildew and growth of dust mites that can trigger allergy, asthma, eczema and cause fatigue for some environmentally sensitive people.

'Natural' ventilation is ineffective, often is unattainable, and is highly undesirable from a comfort point of view. It cannot be counted on to provide fresh air into where it is needed. It becomes excessive in cold windy weather, especially in three-storey dwelling units with a chimney for open combustion appliances. Conversely, in mild weather, smaller single-level dwelling units with radiant or baseboard heat may have little or no infiltration into some rooms.

Designers often prepare graphics showing how cross ventilation and airflow could be achieved by placement of windows and doors. This may happen at some times of the year, when conditions are appropriate and occupants open the windows and doors. Regrettably, air doesn't know it has to follow those arrows, so if there is another path of least resistance, the air will go that way.

In a commercial or institutional building, 'natural' airflows could well be an appropriate way to address some of the ventilation needs, but these

☞ *Why do we need to ventilate our homes and buildings? The purpose of ventilation is to maintain healthy indoor conditions for occupants.*

☞ *Ventilation for occupants must not be confused with ventilation requirements for the structure or combustion air requirements for combustion equipment, which is part of the heating system.*

☞ *Every day, an adult inhales about 54 pounds (24 kg) of air, compared to about 5 pounds (2.2 kg or 2 litres) of water and 1 pound (½ kg) of food (dry weight). Although air is our body's most important environmental intake, we give little thought to air quality.*

types of buildings have different environmental loads and known occupancy loads to make these flows happen. The situation in a home is entirely different. And we need not forget that in most of Canada, most of the winter, conditions are less than ideal for introduction of fresh untempered air.

Codes are moving to requiring ventilation rates based on occupancy – typically using bedroom count as the counter because it gives a good reflection of number of people that could be in the home, since it is the number of people, and not home size, that matters. The Energuide for houses rating system makes an assumption that 0.3 air changes per house is needed – this takes into account mechanical ventilation as well as natural airchange. Houses normally do not need this much ventilation all the time, although it has been recognized, based on a statistical analysis of average Canadian home size, that about 0.3 air changes per hour (ACH) for the average modestly sized house is a suitable minimum level for health and comfort. If this rate cannot be achieved, most households will experience poor indoor air quality and high humidity levels at some times.

If today's homes relied only on the natural air leakage through the building envelope for fresh outdoor air, then 70% of them would have less than 0.3 ACH over the heating season, and 90% would have at least one month when the air change rate would be less 0.3 ACH. Of course, this would result in maximum airflows in colder weather, and insignificant flows during mild weather conditions.

Table 1: CSA F326 Ventilation capacity

Supply	
Master bedroom	20 cfm
Other bedrooms	10 cfm
Living room	10 cfm
Other habitable rooms	10 cfm
Kitchen	10 cfm
Bathroom	10 cfm
Utility	10 cfm
Basement	20 cfm
Exhaust	
Bathrooms	20 cfm
Kitchen	60 cfm

- System must provide balanced ventilation
- Total ventilation capacity is the larger of supply or exhaust
- System must have ability to operate at 50% of capacity
- Metric conversion is:
10 cfm = 5 L/s

Heating Season Mechanical Ventilation Requirements

The National Building Code requires that every house must have a mechanical system that complies with CSA Standard F326 "Residential Mechanical Ventilation Requirements." This is a performance standard that offers flexibility for those experienced in ventilation system design. However, because it is a performance standard, it requires professional design to prove compliance. That is why prescriptive alternatives that meet the performance requirements have been written into the code. As a result, Section 9.32 (Ventilation) offers a choice of "prescriptive" and "good practice" options for compliance with ventilation requirements.

There is some debate about the criteria set out in F326, and it could be updated, but the standard is still based on scientific criteria related to the amount of air an individual requires. That is why ventilation capacity is based on a room count rather than being scaled on the basis of the size of the house. Larger houses don't automatically have larger occupancies, rather they have larger rooms for the same number of occupants.

Ontario and BC have modified Section 9.32 significantly, changing minimum ventilation requirements, although both maintain the reference to CSA F326 as a code compliant standard. However, any builder building a certified R-2000 home or Built-Green Platinum home will automatically have to follow the F326 requirement, as that is part of those program requirements.

System Capacity

The ventilation system capacity is essentially related to the number of people in the house rather than to the volume of the house. Total system capacity is based on the number and type of rooms. For systems in full compliance with CSA F326 (typically this is an HRV system) the system is sized as noted in table 1. Although the system capacity is based on the room count, the system must be capable of operating at half speed. For example, a three-bedroom house, with family room, recreation room, two bathrooms and basement requires a total ventilation capacity of 130 cfm (65 l/s) and will normally be operated at about 65 cfm.

The minimum NBC system is sized based on the number of bedrooms in the house (see table 2). Ventilation can be supplied by a single fan or combination of fans, but clearly labeled controls must allow the airflow to be reduced to 50%. If the principal fan is controlled by a dehumidistat or other automatic control, a manual switch must be able to override the automatic control.

☞ *Good ventilation is invisible, and imperceptible, hidden and understood by few. Its health benefits are measurable but of special concern to about 25% of the population with some form of respiratory ailment.*

☞ *Most houses fail to meet the most basic Code ventilation requirements (which don't always guarantee good indoor air quality), and some quite hazardously. One of the biggest problems is that designers, builders and building inspectors don't understand the ventilation code so they ignore it.*

Protection Against Depressurization

Exhaust fans can cause spillage of combustion products from combustion appliances if the house is depressurized, or draw soil gases into the house, especially in an airtight home. The depressurization limit set by CSA F326 is -5 Pascals when there are spillage susceptible appliances, or -10 Pascals when there are no naturally vented appliances.

Appliances vulnerable to pressure-induced spillage are those that draw combustion air from the house, and that are vented through a natural draft chimney. Examples include older gas furnaces and water heaters with a draft hood, oil furnaces with a barometric damper, open fireplaces and wood stoves. Appliances such as gas furnaces and water heaters with induced draft venting systems and the "sealed combustion" oil furnaces are resistant to spillage and do not require make-up air openings.

Most fireplaces are vulnerable to spillage, even those with so-called "airtight" glass doors and outside combustion air intakes, because "airtight" doors are not really airtight. Gas stoves are not required to be vented, but for occupant health and moisture control they should always be vented to the outside. Their operation will not be affected significantly by depressurization of the house so make-up air openings are not required.

Builders must understand the importance of proper make-up air, especially when large capacity exhaust fans are installed into a home since, in the end, it is the builder who will be held responsible, and not the appliance manufacturer who sells the large capacity exhaust fan. It doesn't help that those appliance manufacturers rarely offer make-up air kits, nor do they make it easy to tie in make-up air kits.

Heat Recovery Ventilators

The National Building Code does not require the use of a heat recovery ventilator, but some local jurisdictions are beginning to mandate it. If an HRV is installed, manufacturers' installation requirements, including balancing and sizing of air flows must be followed. When operating at the required rate, the two air streams must be balanced within 10% of each other. ☼

Letter to the Editor

Re: Ventilation and indoor air quality, Solplan Review June 2010 (No.152)

Can we take your suggestion of moderating air flow rate based on incoming air temperature one step further – "purging" the house during the warmest hours of the day, perhaps even slightly pressuring the house, and only use the HRV for bathroom exhaust during the other colder hours? In this case we would have to be doubly sure that there's no leakage into cold attics etc.

And if the HRV is operated by photovoltaic (PV) generated electricity, except for periods with high moisture loads, then wouldn't it be natural that we'll have more ventilation when the sun is shining?

Wilma Leung
Vancouver

You raise an interesting idea, especially for those trying to achieve net zero energy housing, and count on solar-generated electricity. While the idea may have some application, unfortunately most ventilation loads actually occur at night when everyone is home. Just as we don't breathe intermittently, it is dangerous to rely on intermittent ventilation.

In a very large home with small occupancy, there may be some validity to having smaller or frequent intermittent air changes because the concentration of pollutants is not likely to rise to questionable levels. However, in small homes, the volume is smaller for a similar occupancy so a continuous air change becomes much more important since the whole point for ventilation is to provide fresh air for occupants when they are in the home.

As to possibly pressurizing the house during air change, that is a dangerous idea because of the danger of pushing warm moist air outside into the construction assembly, where condensation could take place. Other than a spacecraft, with all the special care and attention it gets, it is simply impossible to construct a perfectly airtight building envelope. Ed.

Energy Efficiency

We need energy to survive, to fuel our life. We have become so dependent on a reliable energy supply in various forms that most of us are no longer aware of it. With energy available in a seemingly unlimited supply every time we flick a switch, turn on the gas valve, or squeeze the fuel pump at the gas station, it seems that we have become oblivious to the supply challenges, even though there has been much discussion about resource limits and climate change impacts.

The mere mention of energy efficiency or energy conservation still generates images of suffering – doing with less, turning down thermostats and being cold in the winter, having to be bundled up in fleece and sweaters or sweltering in the summer without air conditioning, or sitting in dimly lit rooms.

Energy conservation does not mean doing without or suffering. It does not automatically mean a reduction in the standard of living or lower comfort. Energy conservation refers to the efficient use of energy, which will conserve resources for the future, reduce environmental degradation and play an important part in addressing impacts on climate change. It can be achieved by designing energy efficient equipment and systems that reduce energy consumption. It is using less energy to provide the same level of service.

About 17% of all energy use in Canada is accounted for by the residential building sector, so the design of houses has a big impact on the overall energy use. Although minimum construction standards have improved in recent years and our new homes have become more energy efficient, overall residential energy use is still increasing. There is still room for improvement.

Upgrading a home's insulation for example is still a key step in reducing the building's heat loss. This reduces the amount of energy needed for heating and cooling and helps achieve and maintain a more comfortable temperature. A well insulated and airtight building envelope is one of the most economical and effective ways to achieve high levels of energy efficiency. Because an improved building enclosure involves no moving parts, it delivers benefits year in and year out irrespective of energy price wars, available service personnel to provide equipment maintenance, or future replacement needs. With the addition of mechanical ventilation, the quality of indoor air is also improved.

Today we are seeing a worldwide interest in net zero energy homes. A net zero home brings together energy efficient passive solar home design with a range of state-of-the-art construction techniques, products and systems to significantly reduce the home's energy consumption. Renewable energy technologies are then integrated into the design to help meet household needs for electricity, space heating and hot water. The result is an energy- and resource-efficient home with low environmental impact that aims to produce as much energy each year as it consumes.

Net zero energy homes do not need to look like spaceships. CMHC's EQuilibrium houses are showing that homes with net zero energy consumption can look like a regular home and can fit into any neighbourhood.

Builders and designers may not have much say on the appliances and equipment the homeowner will bring into the house or how they will operate the house, but they can have an influence on overall energy performance of the home. One approach that is being used is to provide opportunities to reduce electrical consumption through features such as "green" plugs. These are electrical circuits that can be shut down from a central location when not in use, thus avoiding the electrical draws from inactive equipment that might still be drawing electricity.

Although our homes have become much more efficient in the past generation, there is more that can still be done. Energy conservation is still the most economical solution to dealing with global energy and environmental challenges. ☼

R-2000

For information on the R-2000 Program, contact your local program office, or call
1-800-387-2000
www.R-2000.ca

Features of a highly energy efficient home

- Climate and site-specific house design
- Optimizing passive solar design for heating and cooling
- Usage of natural daylight
- Energy and resource-efficient construction methods, materials and appliances
- Integrated renewable energy systems
- Healthy building materials and finishes
- Energy-efficient appliances and lighting
- Integrated renewable energy systems such as photovoltaics, solar thermal and ground-source heat
- Water conservation, rainwater harvesting and water reuse strategies.

Spray Foam Insulation 201

In the last issue of Solplan Review, we discussed spray foam insulation. This issue, we thought it appropriate to continue with some additional comments, especially since spray foam insulation has started to become so common in residential construction.

Spray foam products are technically well understood and generally properly applied. For many in the residential construction industry spray foam insulation has become a wonderful new product – it is promoted and widely for use to air-seal cracks and voids in the building enclosure, to fill minor cavities in wall and floor penetrations, cracks and expansion joints to attain a more airtight building. Cans of the material are sold by the caselot in every hardware and building supply store in the country.

Increasingly, we are seeing spray foam insulation used for whole house insulation. Because of exposure on TV shows, some people would like to do foam applications much like other do-it-yourself product installations. Some products, mainly in the US, are offered in contractor-sized batches that make it possible for do-it-yourself foam applications. Packages, such as Dow's FROTH-PAK™ Foam Insulation, are sold in kits that can yield hundreds or even thousands of cubic feet of product. At these quantities, it sets up the condition for unqualified applicators installing the material inappropriately.

Safety concerns

There are serious concerns about proper application of spray foam products. Recently, there have been a few instances in Canada where homes under construction caught on fire – in one case, resulting in the total loss of the home. While fires breaking out during construction are, unfortunately, not altogether uncommon, the indicators are very strong that in a few the fire broke out during, and as a result of, the application of spray foam insulation. The spray foam industry even has a term for this – 'burn out' – which is used when referring to the self-combustion of spray foam during application.

Generally, there are few problems with most professionally installed spray foam applications. But as everyone knows, nothing in this world is perfect, and problems do occur. In the commercial construction sector, where projects are larger and insulation contracts are large, third party quality assurance audits and inspections are common.

Up to now, most of the high profile discussions have focused on a discussion of differences between open cell and closed cell foam, whether or not they require a vapour barrier, whether or not they can be used on a roof with an air space or without and so on. However, there is generally very little discussion about potential safety concerns during application.

Builder awareness

We need to reinforce the point that spray foam materials have specific technical application requirements that must be adhered to. All licensed contractors must meet the installation requirements of the CAN/ULC S705.2, and all manufacturers have a third party agency involved in a comprehensive quality assurance program.

Builders are aware of certain products and processes on a job site – such as the use of propane torches, kerosene heaters, gasoline, etc., because of their potential to create serious property damage and loss of life. Spray foam should be added to any list of potentially dangerous products – and builders need to be aware of its proper application as well as the need to deal with properly trained applicators.

In the case of residential construction, many jobs are small, so spray foam applicators may fall under the radar of third party quality assurance reviews. Given the nature of the industry – with many smaller players – there may be temptations to expedite application and cut corners.

High Temperatures Generated

Spray foam insulation is a specialized product that requires high temperatures to generate steam that helps generate the cells that define the nature of open cell foam insulation. Depending on manufacturer and product, this may require temperatures in the range of 100°C (212°F), but should not exceed 250°F. Too high or too low a temperature can lead to improper cell formation that can lead to shrinkage of the product.

Spray polyurethane foam is an organic material and all organic materials burn. Medium density spray polyurethane foam contains a fire retardant so that the flame spread is less than

500 (when tested in accordance with CAN/ULC S102 *Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies*). It is considered to be a combustible insulation under the building code, although it does have a fire retardant in it. The Building Code also requires a thermal barrier to be put over all foam insulation (½" drywall, plywood and OSB are acceptable thermal barriers).

Foam Thickness Issues

Open cell foam (half-pound foam) generally needs to be applied at least three inches thick to generate the temperatures that will create the cellular structure that gives it its properties. It is sufficiently permeable that it can be safely installed in thickness of up to ten or twelve inches at a single pass.

Closed cell foam (two-pound foam) is created by a chemical exothermic reaction. The exothermic reaction (one that generates heat) is affected by the temperature and pressure settings of the spray equipment, the relative humidity, ambient temperatures, altitude, barometer, chemical makeup, and substrate temperature. If it is installed in very thick applications in a single pass the temperatures generated by the chemical reaction can increase to the extent where the foam begins to char and even spontaneously combust.

That is why closed cell spray foam must not be installed in passes greater than two inches thick, with time to allow the foam to cool before the next application is done. In no case should more than 2 passes (about 4 inches total) be installed in any single day, to allow cool-down.

The thickness of a pass is critical, because the insulation not only generates heat by itself but can also act as an insulator for itself during the exothermic process to contain the heat required for proper cell expansion.

The application thickness has an impact on the cell structure and the density of the foam being sprayed. In a very thin pass the foam does not generate much heat due to the chemical reaction, in part because the substrate absorbs some of the heat from the reaction, and also because there is less chemical to react. Thus spraying a thin pass on a cold concrete wall will end up with a very high-density foam, while spraying a thin pass on a hot concrete wall will end up with a lighter density foam that may be okay for a given situation. This is where trained spray foam applicators and experience pays off.

Causes Of Burn Out

Flash over (burn out) happens when the volatiles in the curing process reach a high enough temperature to ignite. Once ignition occurs, everything burns – the insulation and materials in contact with the insulation. Burn out occurs due to a runaway exothermic reaction caused by too thick a pass or an improperly mixed system.

Another contributing factor is making insulation passes, even if they are the right thickness, too quickly.

There is no substitute for proper training and application technique. Manufacturers' directions should always be followed and proper safety precautions taken no matter what the situation. ☼

Solplan Review Back issues

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Solplan Review
Box 86627
North Vancouver, BC V7L 4L2
e-mail: solplan@shaw.ca

Letter to the Editor

Re: Spray Foam 101: Solplan Review, June 2010 (No. 152)

I have a question regarding the article on spray foam insulation, and another item circulating on the Internet. The article claims using EPS or XPS foam insulation is harmful to the environment and the Solplan article essentially says otherwise.

I find it confusing when I come across conflicting information. I have been told many times to keep an open mind for most things found on the Internet.

Since subscribing to the Solplan review I have come to accept its contents as a solid reference. Could you please comment?

Doug Docherty,
Aldergrove, BC

You raise a very interesting question about the overall embodied energy and environmental impact of building materials. The article you are referring to is based on data prepared and published in the June 2010 issue of Environmental Building News (EBN). It shows that the global warming potential of certain foam insulation materials can be high, and could counteract much of the environmental benefit of using those insulation materials in a building.

EBN executive editor Alex Wilson examined how the hydrofluorocarbon (HFC) blowing agents used in extruded polystyrene (XPS) and most closed-cell spray polyurethane foam (SPF) results in very high "global warming potential" for these insulation materials.

All insulation saves energy and thus helps to reduce the emissions of carbon dioxide, the most significant greenhouse gas. However, insulation materials themselves are also responsible for greenhouse gas emissions, or global warming potential (GWP). Some of that GWP results from the energy used in manufacturing and shipping insulation (embodied energy), but a far greater GWP comes from the blowing agents used in XPS and most closed-cell spray polyurethane. The GWP results from the HFC blowing agents used in these two types of insulation: HFC-134a with XPS and HFC-245fa with most closed-cell SPF. As greenhouse gases, these two blowing agents are, respectively, 1,430 and 1,030 times as potent as carbon dioxide. The EBN analysis assumes that 50% of that blowing agent will escape into the environment over the life of that insulation.

The article presents data showing, for example, that a four-inch layer of XPS added to a 2x6 wall insulated with cellulose, will result in a 65-year payback for the 'lifetime GWP' of the XPS.

It's a complicated issue, but one that we should pay attention to. For most applications, there may be alternative insulation materials available that offer fast paybacks on the lifetime GWP. Except for XPS and HFC-blown SPF, the payback for the lifetime GWP of insulation materials is low — on the order of two or three years at the most. For example, four inches of polyisocyanurate (R-25) has a lifetime GWP payback of about 2.7 years. By comparison, one inch of XPS has a 36-year payback.

If we're building highly insulated buildings and doing so in part to mitigate global warming, we should use insulation materials other than XPS or SPF – at least until these insulation materials are produced with blowing agents that have far lower GWP. Low-GWP blowing agents are likely to be available in the next few years, though it is unknown how quickly XPS and SPF manufacturers could convert to these or other compounds.

There are lots of good alternatives with lower environmental impact. Polyisocyanurate (a foil-faced rigid insulation material sold under such tradenames as Thermax, ACFoam, and Rmax) is made with pentane as a blowing agent which has a very low GWP. Expanded polystyrene (EPS or beadboard) is also made using pentane as a blowing agent. Open-cell spray foam, such as Icynene, uses water as a blowing agent. Fiberglass, mineral wool, and cellulose do not use blowing agents at all.

However, XPS and closed-cell spray foam has excellent performance properties controlling moisture migration and airflow through the building envelope, so if they are being substituted with a different material, these building science issues have to be addressed carefully. Ed.

Don't Do It Yourself!

Recently, on the Greenbuilding web discussion forum, a member acknowledged the benefits of spray foam, and asked group members for do-it-yourself foam insulation kits and which one may be best, as they wanted to insulate their garage.

DIY kits are available in the US, but should be discouraged. It is quite likely that the DIY installer may not understand the importance of proper installation practices, ignore installation instructions, and apply the foam in a manner that could lead to overheating and even fire.

Building Enclosure Performance

Moisture damage seen in a 1950s vintage building during renovations.

The leaky condo crisis in Vancouver has generated much trauma, angst, and speculation, as well as study and research into what happened. One significant impact has been a much better understanding of the importance of building science, and the need to apply it to our construction practices and details. It has led to much research over the past years.

A unique research project was initiated by Mark Gauvin, President of Gauvin 2000 Construction, a Coquitlam BC-based general construction company. Over their 37 years in business, they have built or renovated a mixed portfolio of buildings that include offices, churches, schools, and retail premises in addition to many residential units and houses. The unique aspect of this project is that it is a mid-sized general construction company investing their resources to determine, from a contractor's perspective, what happened, and how to build better.

To aid in the effort, they joined forces with two heavyweights of the building science world: Joe Lstiburek, principal of Building Science Corp., and John Straube from the University of Waterloo. A couple of product suppliers joined the team, providing a limited amount of funding support and materials, but their participation was on the condition that it was 'hands-off'.

The project built a test hut – placed on the roof of the company's office building in Coquitlam – which provided an accessible, secure location in the middle of the urban environment that has experienced a lot of problems. The test hut was designed with the ability to test 7 wall assemblies on each orientation (for a total of 28 assemblies) plus three roof assemblies with two orientations (north and south facing).

Coquitlam test hut sits on the roof of the office building.

The driving force for the project was the observation that while the building envelope problems were observed on recent projects, which had industry claiming that recent code changes, requiring higher insulation levels and more care and attention to air and vapour barriers, were the possible source of the problems, many of the same problems were noticed in older buildings when renovations were done.

Built in 1950 - seemingly well maintained building - rot found behind poorly designed and installed flashing,

Mark Gauvin noted that, on the surface, older buildings did not seem to experience the same moisture problems as newer buildings. However, as a general contractor, when they got involved with renovations on older buildings – they noticed lots of problems. Some of the older buildings were of a vintage that many in the industry held up as examples of successful durable construction practices.

Even simple, supposedly better performing buildings from the 1950s were found to have leaky windows without any head flashings or sill pans, no air seals around windows, metal frame windows without sealed corners, single layers of reverse lapped sheathing paper, full of holes, plenty of water stains on wood sheathing, and poor or non existent flashings around trim details and material transitions.

	1970's	1990's	1990's	USA	Rain screen		Foam
Framing	2x4	2x6	2x6	2x6	2x6	2x6	2x6
Vapour barrier	Paper	Poly	Paint	Paint	Poly	Paint	Paint
Insulation	R-8	R-20	R-20	R-20	R-20	R-20	R-20+5
Sheathing	3/8" ply	½" OSB	½" OSB	½" OSB	½" OSB	½" OSB	½" OSB
Weather barrier	1 paper	1 paper	1 paper	Drainwrap™	Drainwrap™	Drainwrap™	Drainwrap™
Exterior	Stucco	Stucco	Stucco	Stucco	Stucco	Stucco	Stucco
Drainwrap™ is an engineered Tyvek product that looks like crinkled heavy paper – it has a structure and thickness with vertical grooves to create a capillary break and provide drainage channels. Currently it is only marketed in the US							

Table 1. Construction assemblies tested - each one on each orientation of the building.

So what changed to make buildings more vulnerable? We build with higher insulation levels today. As late as the 1970s, coastal BC practice was to use R-8 paper-backed batt insulation, and this changed in the late 1980s to R-12 with polyethylene, caulked and sealed. These changes led to changes in the drying ability of construction assemblies.

Seven typical wall assemblies were tested – one of the objectives was to see whether the new construction approaches really were a contributing source of problems. Each assembly was representative of typical construction details and practices at the time, and was placed in each orientation, fully instrumented, and monitored for a two-year period. These are summarized in Table 1.

The first year, the indoor temperature in the test hut was kept at a constant 20˚C, but the indoor relative humidity was allowed to fluctuate. There was some controlled wetting allowed at the interior face of the sheathing to simulate a leak. In the second and third year, the indoor temperature was kept constant at 20˚C, and the indoor relative humidity was also kept constant at 50%. The testing has continued, with the indoor relative humidity being kept at a constant 40%, with some controlled wetting of the exterior and interior face of the sheathing.

At the outset of the study, Mark had a sense that the monitoring would show something about how much better the older construction practices were, and that maybe there was validity to industry speculation that the increased insulation and sealed poly air/vapour barriers were a contributing cause of the problems industry was experiencing.

The results were anything but what was expected. The way Mark puts it:

- There is a lot going on inside a building enclosure.
- The laws of physics apply to enclosures.
- Observation is a very useful tool, but to understand, you must measure what you can't see.
- Everything affects something else!

Some Important Points To Keep In Mind

Wood moisture content is a function of relative humidity. Lower temperatures mean higher moisture content. With more insulation in a stud space, the exterior sheathing is colder - close to outdoor temperature - so the moisture content in the sheathing is going to be higher. This means there is less capacity to absorb, store and redistribute moisture, so the sheathing is more susceptible to damage with any additional moisture (such as rainwater).

More insulation means there is less energy flow through the building enclosure, so there is less energy to dry any moisture that may be present, as was the case in older un- or under-insulated buildings.

Twenty years ago, when energy standards were being upgraded, there was not as much awareness of these issues as there is today.

The most important finding is a confirmation that rain screen walls work. The rain screen provides a capillary break, a drainage space, pressure equalization (which reduces the moisture and pressure on the weather barrier) and ventilation of the space.

Vapour Barriers

There has been much discussion about the use of polyethylene for vapour barriers. Polyethylene is very effective for its intended use. It stops the airflow and diffusion of moist indoor air through a wall, and this prevents moist indoor air from reaching cold surfaces, where it can form condensation.

The comparison of the wall with the poly vapour barrier against the paint vapour barrier showed that poly was actually better – there was some evidence of condensation on the interior side of the wall sheathing. However, the old

2x4 wall, R-10 paper backed fiberglass insulation, plywood sheathing – thick layer of frost was seen on the inside of the plywood (wetting is frost melt as wall was opened up).

(1970s style) wall assembly with the paper-backed batt insulation had thick layers of frost on the interior of the sheathing.

What this shows is that vapour diffusion is an important consideration. Vapour barriers (or technically more correct vapour diffusion retarders) are important. However, one must also take into account interior conditions including relative humidity and ventilation. This becomes more important as we build more energy efficient buildings, and use materials other than polyethylene for vapour barriers.

Drying Mechanisms

Moisture on the exterior dries by evaporation of surface water on the cladding, by water vapour movement by diffusion through the cladding and by convection in the space behind the cladding, and air movement through the rain screen cavity. It is this last – the ventilation of the rain screen cavity – that has been found to be a very important drying force. Even small airflows can move significant amounts of moisture. Monitoring and simulation of test assemblies at the University of Waterloo has observed airflows in the range of 1.25 litres/second per m2 through the rain screen cavities – which can be significant aids to drying the assembly.

Walls with exterior foam insulation keep the wood framing warmer and dryer, reducing the potential for condensation, as well as reducing thermal bridging and heat loss. However, it is important to remember that extruded polystyrene insulation has a low vapour permeance, so it is important to avoid conditions that may trap moisture (which could be construction moisture, minor plumbing leaks, and accidental floods) between two vapour barriers. Thus, with exterior foam insulation, it may be necessary to review the type of vapour barrier used, and to use a material that has some degree of permeability to allow the assembly to dry into the interior also. This would include materials such as paint vapour barriers or a 'smart' vapour barrier.

More information

The Coquitlam Test Hut
http://vancouver.buildingscience.com/

Building Science Corporation
http://www.buildingscience.com/

Building and Safety Standards - Gov't of B.C. (BC Building Codes)
http://www.housing.gov.bc.ca/building/

Technical Research Committee News

Canadian Home Builders' Association

New Federal Energy Efficiency Regulations

Residential Boilers

Residential gas and oil-fired boilers are regulated products under Canada's Energy Efficiency Regulations. Natural Resources Canada (NRCan) intends to amend the Regulations to require dealers to comply with more stringent minimum energy performance standards for residential gas and oil-fired boilers imported or shipped inter-provincially, for sale or lease in Canada. The proposed regulations include a reporting requirement for electrical consumption of auxiliary equipment associated with the boilers.

The requirements will call for gas hot water boilers to have a minimum AFUE (Annual Fuel Utilization Efficiency) of 82% and have no constant burning pilot, and an automatic means for adjusting water temperature.

Oil-fired hot water boilers will have to have a minimum AFUE of 84%.

The effective date is September 1, 2010

Air Source Heat Pumps - Reporting Cold Climate Performance

Natural Resources Canada is proposing to amend Canada's Energy Efficiency Regulations to require dealers to provide additional information for air source heat pumps.

Air source heat pumps are a higher efficiency alternative for space heating and are especially important in areas where natural gas is not available. Homeowners using electric resistance heat and who are looking for more efficient equipment in order to reduce heating costs often install an air source heat pump. Central single package, central split using duct work, and multi-split heat pumps would be included in these additional reporting requirements.

As of January 1, 2012, heat pumps manufacturers will need to report the COP for heating and heat output at -8.3˚C (17˚F). Manufacturers generally have this information but have not been required to provide it. As of January 1, 2014, product reporting of the COP (heating) at -17.8˚C (0˚F) will be required. Performance at this level is not measured at present.

Built-Green™ Program Set to Expand

Built-Green is an industry-driven voluntary program promoting "green" building practices to reduce the impact that building has on the environment. It benefits the homebuyer, the community and the environment and is an opportunity for everyone to choose a "green" future. Since it was launched in 2004, the program has enrolled more than 14,500 homes in Alberta and BC. Interest from other areas has led the Built-Green Society to plan to make it available across the country.

The Built-Green program sets out building performance standards, mandatory builder training, and third-party testing and inspections. It encourages homebuilders to use technologies, products and practices that will provide greater energy efficiency and reduce pollution, provide healthier indoor air, reduce water usage, preserve natural resources, and improve durability and reduce maintenance.

The program concentrates on four areas of environmental concern: energy efficiency, indoor air quality, resource use (including waste management), and overall environmental impact.

Built-Green™ Renovations

With the interest in green building practices on the rise, and interest from renovators, the program has launched the Built-Green™ Renovation Program. They have developed a checklist that contains more than 290 action items to choose from and functions as a menu of environmentally friendly action items to include in a renovation project. Along with the checklist, a Built-Green™ Renovation Program Guide for Single Family & Row Houses has been prepared to explain how the checklist should be used. Additional information will be provided through technical seminars.

Both documents are available on the Society's website: *www.builtgreencanada.ca*

Energy Answers

Rob Dumont

There is a lot of talk and some action about supplying electricity for homes using photovoltaic modules. Isn't the demand side of the equation equally important? What about more efficient appliances, lights, etc?

You are quite right. People in their homes don't buy electricity for the sake of passing electrons through their wires. They want the services that electricity provides. A fridge that uses 300 kWh per year can keep their beer as cold as one that uses 2500 kWh per year.

Case Study

Over the years, since we built out home in 1992, I have been keeping track of our electricity consumption. In 1992, there were not very many really efficient appliances, but we did use an all-refrigerator with no freezer compartment, and mostly compact fluorescent lamps. As of 2005, our annual consumption for LAME (Lights, Appliances and Miscellaneous Electricity) ran about 5700 kWh per year or 15.6 kWh per day. I used submeters on 17 electricity using devices in the home to track the consumption. Table 1 shows the consumption values.

For comparison, our electrical utility estimates that the average home in Saskatchewan uses about 7600 kWh per year. In recent years we have started upgrading our 1992 vintage appliances:

Clothes Dryer	1403
Lighting and Misc (outdoor use, car block Heaters, powered TV antenna, doorbell, 6 Smoke detectors, garage door openers, Furnace fan, Space heating thermostat, other Phantom loads, window fans, chargers.)	1193
Stove (rangetop and oven)	847
Chest Freezer with Green Plug	492
Air to air heat exchanger	482
Refrigerator (with no freezer) with Gr. Plug	319
Desktop Computer with CRT Monitor And Inkjet Printer	240
27 inch Cathode Ray Tube Television with VCR and DVD player	118
Microwave	112
Dishwasher (excluding hot water)	91
Glycol pump on solar thermal collectors	85
Clothes washer (Top loader) excluding hot Water	79
Modem and answering machine	61
Second TV set (19 inch)	52
Humidifier (Table top)	44
Toaster	31
CD Player, Radio and Cassette unit	10
Total	**5659 kWh/yr**

Table 1: Annual electrical consumption for lights, appliances, and miscellaneous electricity

The changes include the following:

- New front loading Energy Star clothes washer
- New clothes dryer.
- New Energy Star dishwasher
- New Energy Star chest freezer
- New modem/router
- Laptop instead of a desktop computer

	Consumption of Old Appliance Excluding hot water (kWh/yr)	Consumption of New Appliances Excluding hot water (kWh/yr)
Clothes Washer	79	80
Clothes Dryer	1403	950
Dishwasher	91	90
Chest Freezer	492	326
Modem	61	44
Computer/printer	240	60
Subtotal	**2366**	**1550**

Table 2: comparison electrical consumption of old and new appliances

Comparison of Old and New Appliances

With the newer appliances, the consumption for LAME dropped 816 kWh per year. The newer LAME annual consumption for the house is 4843 kWh per year. The biggest users continue to be the clothes dryer at 950 kWh per year and the stove at 847 per year. If we were to air dry the clothes, the consumption would drop to about 3893 kWh per year.

What sort of LAME consumption values have been achieved with other low energy houses in Canada?

The Factor 9 Home in Regina had a monitored value of 3542 kWh per year for LAME.

The Mill Creek House in Edmonton, a Net Zero House with very energy conserving occupants, has cut its LAME use to 3139 kWh per year.

To illustrate the importance of conservation, let's look at the relative costs of systems that would supply all the electricity annually to houses of different conservation levels. The following table assumes that the installed cost of a photovoltaic (PV) system is $7 per peak watt, and that the annual production is 1 kWh per peak watt.

As can be seen from the table, cutting your electricity consumption in half (from 7600 kWh per year to 3800 kWh per year) results in a capital cost saving of $26,600 if you are using PV.

With numbers like that, it is difficult to overstate the importance of energy conservation.

Annual electricity consumption kWhr per year	Capital Cost of PV system to supply all the electricity
7600	$53,200
5600	$39,200
3800	$26,600

In car driving there are hypermiling techniques to squeeze more kilometres out of a litre of fuel. What are some hyper-efficiency techniques for electricity use?

Recently my wife and I bought a 2008 Toyota Prius. I was looking on the internet and found some ideas for getting great mileage from the Prius. The techniques include both behavioural techniques (coasting to stop signs, gently accelerating, limiting the use of air conditioning, planning your day to minimize small trips) and inexpensive modifications (running tires at maximum pressure.) For safety reasons, tailgating large trucks is not recommended. One of the neat features on the Prius is a continuous readout of the gas mileage in litres per 100 km. A graph of your energy usage over the last half hour is also available on the readout. "What gets measured gets managed."

For electricity use in a home, here are a few hyper- efficiency techniques:

1. Use an instantaneous readout device to see what electricity you are using. "What gets measured gets managed." There are several devices on the market—TED, Powercost Monitor, Black and Decker for less than about $150. These devices will measure the whole house electricity use. Typically one can save about 10 to 15% in electricity just by having the feedback from these devices.

2. Use a Kill-a-Watt device to measure the consumption of plug loads in your house. The device is available on the internet for about $30.

3. Minimize phantom electricity use (leaking electricity). Put electronic devices such as the TV, DVD, VCR, Cable box, internet router, etc on power bars to minimize their standby power use when no one is around.

4. For outdoor lights, use motion sensors to turn the lights on, rather than energizing the lights continuously.

5. Use very efficient white appliances. Standard Energy Star is not enough. Use the very best Energy Star rated clothes washers, clothers dryers, refrigerators and freezers. Look for Energy Star Tier 3 appliances. In refrigerators, the Tier 3 appliances use 30% less energy than the current standard. Here is the US web page for Energy Star refrigerators: *www.energystar.gov/index.cfm?fuseaction=refrig.search_refrigerators;* Canadian Energy Star listings can be found at:

http://oee.nrcan.gc.ca/residential/energystar-portal.cfm

6. Use smaller appliances where appropriate. Smaller refrigerators and freezers use less electricity.

7. Use ultra efficient light sources. Light emitting diode (LED) lamps are now on the market. I recently bought an 8 watt downlight for $15 retail. The lamp is rated for 40,000 hours, which is much longer than the 6,000 to 10,000 hours from most compact fluorescent lamps. $15 for a lamp is not cheap, but considering the high efficiency and long life, the lamp is a bargain, especially if you are using PV generated electricity.

8. Use a laptop computer instead of a desktop machine. You'll save about 2/3 or more on electricity use.

9. Use an inkjet printer rather than a laser printer.

10. Unplug any electricity device that is not being used. Alternatively, use a power bar with a switch. Turn lights off. You cannot save any more electricity than by turning something off.

11. Consider alternative ways of drying clothes. Staber and Whirlpool make a drying cabinet which is different from a traditional tumble dryer. It uses room air to dry out clothing. These are apparently very popular in the Scandinavian countries.

There is still much to be done to improve the energy efficiency of appliances. About 20 years ago I read of a fellow in the New England states who made a zero energy refrigerator. Yes, zero energy! He started out with a modified refrigerator cabinet that had about R50 polyurethane insulation added to the shell of the unit. He then placed the refrigerator on the north wall of his house. On the outside of the house he mounted an insulated 45 gallon barrel filled with water. In the winter this barrel would freeze and store a large amount of "coolth". To transfer heat from the superinsulated refrigerator box to the ice barrel, he used a thermosyphon copper loop filled with glycol and water. Voila! The refrigerator (which lacked a freezer compartment) was able to work over the entire year in Vermont.

Consider the case of the Canadian Prairies—our annual average temperature outdoors is about + 2 C. Yet the ideal temperature in a refrigerator is about +4 C. In prairie conditions, on average you have to add heat to a refrigerator relative to outdoors.

Let's get on with more efficient appliances and lighting! ☼

NRC·CNRC

High-Performance Thermal Insulation – Better Than Ever

By Phalguni Mukhopadhyaya

The continuing search for energy efficiency in buildings points to the use of high-performance insulation as a promising way to reduce energy consumption for space conditioning. One high-performance system, the vacuum insulation panel (VIP), is of particular interest owing to its exceptional insulating value, up to R-60 per inch or even higher.

Despite their high insulating values, VIPs have been slow to make inroads into construction because of three drawbacks – cost, the need to protect them against puncturing, and the absence of long-term performance data or a procedure to predict long-term performance. The National Research Council Institute for Research in Construction (NRC-IRC) has been studying these issues in collaboration with other national and international research bodies, and stakeholders in building construction.

The Technology

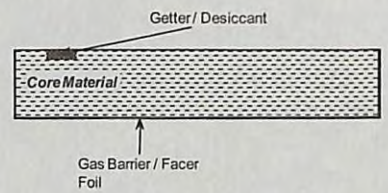
Vacuum insulation panels (VIPs) are elements whose performance is based on the fact that the absence or reduction of gaseous pressure inside an open-porous material increases its thermal insulating potential. Accordingly, a VIP is made with open porous core materials enclosed in an impermeable gas barrier and has three major components:

1. The core material is open-pored (and therefore evacuation-capable) and must be able to withstand the external load caused by atmospheric pressure. Ideal core materials should have an open cell structure, very small pore diameter, resistance to compression due to atmospheric pressure, and very high resistance to infrared radiation. Nano-structured materials have been found to require the smallest degree of vacuum that has to be maintained.

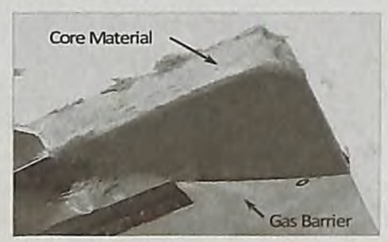
2. The gas barrier/facer foil provides the airtight and vapour resistant enclosure for the core material. The long-term performance of VIP is very much dependent on the performance of the gas barrier/facer foil.

3. A getter/desiccant is added inside the core material to adsorb residual or permeating atmospheric gases or water vapour in the VIP enclosure. The addition of the getter/desiccant increases performance and longevity.

These three components are shown in Figure 1.



(a) Schematic



(b) Photo (gas barrier cut from a corner)

Figure 1 - VIP components

Advantages of VIPs

The thermal insulating capacity of VIPs is up to 10 times higher than that of conventional insulating materials (Figure 2). This property makes the panels particularly useful in applications where space is at a premium or where a higher insulating value is desired.

Search for Alternative Core Materials

Long-term thermal performance of the vacuum insulation panel depends primarily on the gas barrier/ foil facer and the core material. While the gas barrier helps to maintain the airtight and vapour tight environment, the core material provides the insulating capacity. Studies at NRC-IRC have indicated that commercially available vacuum technology and foil materials provide effective resistance against air and vapour permeation through the gas barrier seams.

Cost remains one of the biggest drawbacks to widespread adoption of VIP's in construction. NRC-IRC is now examining alternative core materials as a way of reducing the cost.

Dr. Phalguni Mukhopadhyaya is a senior research officer in the Building Envelope and Structure Program of the NRC Institute for Research in Construction.

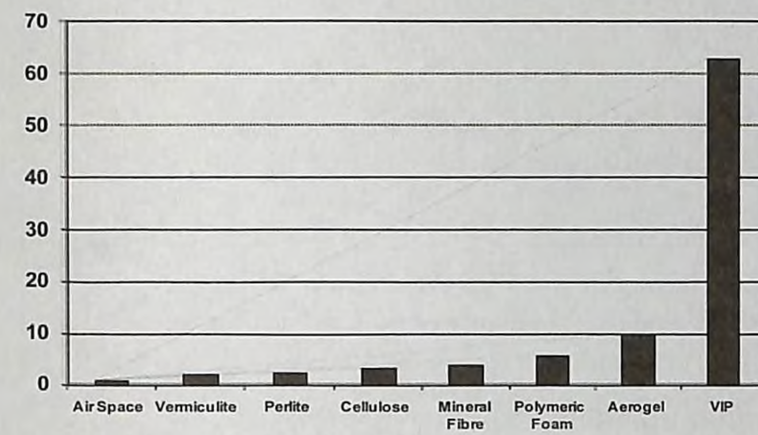


Figure 2 - Thermal resistivity of VIPs compared to common insulating materials

Building Applications

Protection against puncturing is related to the fact that the high-level performance of VIP's is based on maintenance of the vacuum. Therefore, VIPs must be well protected from mechanical damage due to functional loads or construction activities such as nailing. On the positive side, even if a vacuum were to fail completely, the thermal resistivity of the core material is at least as efficient as that of any standard insulation material. However, when VIPs have been used in situations where the amount of space available for insulation is limited, vacuum failure could result in an insulating value that is below requirements.

Accordingly, the VIP development process will need to include handling and quality control procedures and standards. In addition, several concepts have emerged that will be investigated. For example, an obvious use for VIPs is to insulate precast cladding panels, where mechanical protection is provided to the insulation by the concrete or any other rigid cover.

For frame construction applications, the use of carbon fibre protection for VIPs is being investigated. Another possibility is the use of conventional batt and rigid insulations to keep VIPs centred in envelope cavities and remote from potential damage from fasteners. Furthermore, these additional materials would enhance the overall insulating value and reduce thermal bridging at junctions of VIP panels.

Outlook for VIPs

Based on the research efforts of NRC-IRC and others, it appears that vacuum insulation panels hold great promise for use in buildings in a way that could substantially reduce energy consumption.

For the next five to ten years, it is expected that VIP's will remain more expensive than conventional insulating materials with the same R-value. With time, it is expected that the cost of VIPs will decrease and the product will become more economically attractive as a result of improved automation of the manufacturing processes and increased volume of production leading to the economies of scale already achieved with conventional materials.

In the near term, it is likely that products such as floor heating systems, exterior doors and prefabricated facade elements will make use of the high insulating value and slim profile of VIP's.

Several prototype projects have been completed or are being carried out in Europe using VIP technology and at least one in Canada. For information about international research efforts, general properties and uses of VIPs, visit:

www.ecbcs.org/annexes/annex39.htm#p

For further information about NRC-IRC research on VIP's, contact Phalguni Mukhopadhyaya at:

Phalguni.Mukhopadhyaya@nrc-cnrc.gc.ca